Time and leap seconds

TEC/NOT/072

This technical note describes how leap seconds and year information are set by Curtiss-Wright products and is divided into the following sections:

44.1 Time standards available for use with Curtiss-Wright products

Now that three standards of time can be used in the Acra KAM-500, switches, and recorders, better care can be taken to account for leap seconds. Leap seconds are adjusted automatically by AXN. AXN programs a serial EEPROM transparently when a leap second occurs.

The three standards times are:

- **TAI:** Temps Atomique International is the international atomic time scale based on a continuous counting of the International System of Units (SI) second. TAI is currently ahead of UTC by 37 seconds. TAI is always ahead of GPS by 19 seconds. Precision Time Protocol packet timestamp is based on TAI.
- **UTC:** Coordinated Universal Time, formerly known as Greenwich Mean Time (GMT), or Zulu time. Local time differs from UTC by the number of hours of your time zone. UTC is occasionally adjusted by lengthening or shortening the last minute of a month by one second because it is based on earth time. The world does not rotate uniformly, which causes a drift in UTC time. Of the 24 leap seconds that were added from 1972 to 2008, most were conveniently applied at the end of the last minute of the year. However, nine occurred on the 30th of June in various years. IENA packet timestamp time is based on UTC.
- **GPS:** Global Positioning System time is the atomic time scale implemented by the atomic clocks in the GPS ground control stations and the GPS satellites themselves. GPS time was zero at 0:00, 6-Jan-1980 and since it is not perturbed by leap seconds GPS is now ahead of UTC by 18 seconds.

In summary, the leap seconds for November 2023 are:

TAI = UTC + 37 seconds

GPS = UTC + 18 seconds

TAI = GPS + 19 seconds

44.2 Packet timestamps

AXN and Acra KAM-500 offer two types of Ethernet packets, that is, IENA and iNET-X. (AXN also supports Chapter 10 but this is not discussed in this document.) For more information on Ethernet packets, see *TEC/NOT/067 - IENA and iNET-X packet payload formats*.

This document refers to the timestamps of these packets.

44.2.1 IENA timestamps

These 48-bit timestamps are associated with the oldest unit of data in the payload. It represents the time of the current year, in microseconds, since the 1st January. In the case of analog data, the timestamp relates to the earliest sample contained in the payload.

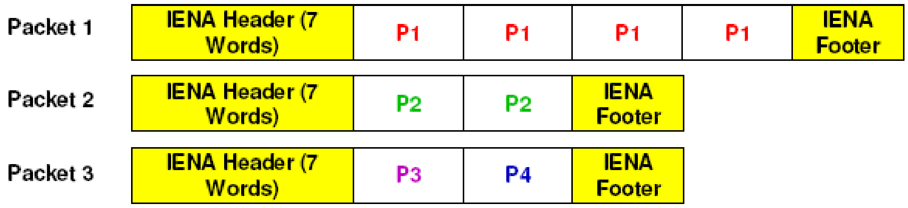

Figure 44-1: IENA packet content

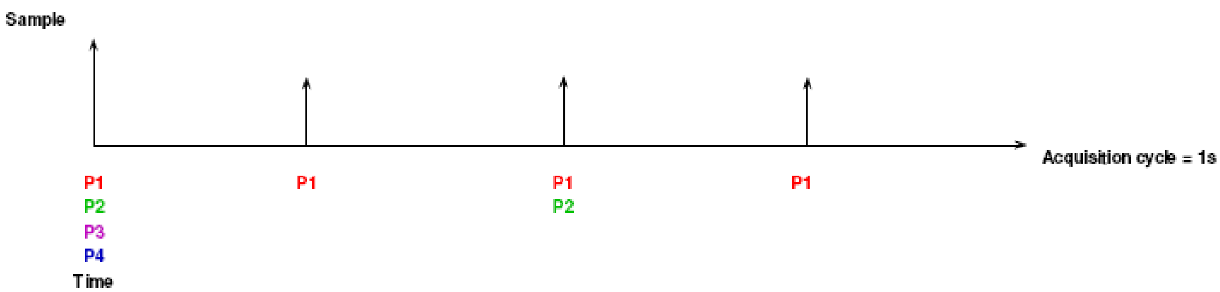

Figure 44-2: Example of IENA timestamp

44.2.2 iNET-X PTP timestamps

These 64-bit timestamps are associated with the oldest unit of data in the payload. In the case of analog data, the timestamp relates to the earliest sample contained in the payload. For bus monitor data, the timestamp relates to the first and earliest bit or message captured on the bus. The time format used is unsigned IEEE 1588 Precision Time Protocol (PTP) format using PTP epoch where:

- Bits [0:31] time = second count since January 1st 1970

- Bits [32:63] time = nanosecond count since start of second

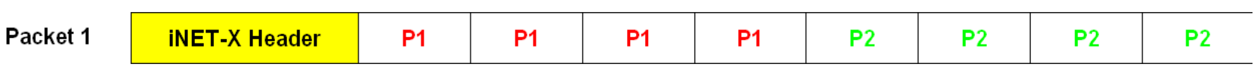

Figure 44-3: iNET-X packet content

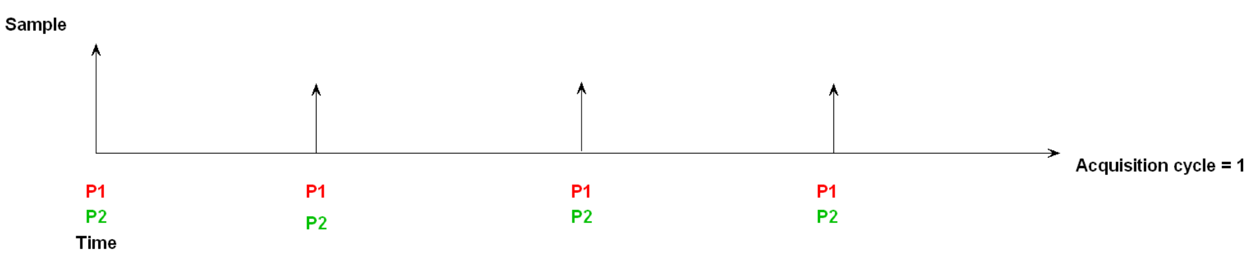

Figure 44-4: Example of iNET-X placed packets timestamp

44.3 Leap seconds

Leap seconds are used to align UTC with various reference times (for example, GPS, PTP). For correct translation from any reference time to UTC the correct number of leap seconds must be applied during the conversion. The International Earth Rotation and Reference Systems Service adds leap seconds to UTC at regular intervals. Typically leap seconds can be added on June 30 or December 31, but the UTC standard provides for leap seconds to be applied at the end of any month.

44.3.1 IENA and PTP: mid-year leap seconds and IENA time

The network switch PTP Grandmaster reports the number of seconds by which UTC currently differs from PTP time, but does not report whether any of these differences occurred since this year began.

A problem arises when an IENA transmitter, such as a KAD/BCU/105 or KAD/BCU/140, starts transmitting after a leap second has occurred during the current year. IENA time is based on the start of the current year in UTC. This means an IENA transmitter must calculate when the current year began.

If an IENA transmitter starts to synchronize with a network switch PTP Grandmaster during the second half of a year, it does not know whether a leap second was applied in June of the current year.

For this reason, the IENA transmitter always calculates the start of the current year by assuming every hour since the start of the year has had 3,600 seconds.

44.3.2 iNET-X: network switch PTP Grandmaster and IRIG

Year data is not transmitted in IRIG. As iNET-X requires year data, it is set by the network switch PTP Grandmaster.

44.3.3 iNET-X: network switch PTP Grandmaster and GPS

GPS requires the number of leap seconds between UTC and GPS. When first powered up, if the GPS onboard receiver does not know how many leap seconds to apply, within 12.5 minutes it receives a correction from GPS satellites. When this is applied, the time steps back the appropriate number of leap seconds.

For example, if the leap seconds are not set, or are not set with the exact same leap seconds as on the PTP Grandmaster, the KAD/BCU/XXX Ethernet controller module synchronized with PTP resets because it must adjust its clock by more than 500µs. This causes data acquisition to cease until the next two-second boundary, that is, packets are lost.

This happens once after power-up and once when the module synchronizes with a time master.

44.3.4 Time code modules with GPS input and leap seconds

A time code module with GPS input, such as the KAM/TCG/105, requires the number of leap seconds between UTC and GPS. When first powered up, if the GPS onboard receiver does not know how many leap seconds to apply, within 12.5 minutes it receives a correction from GPS satellites. When this is applied, the time steps forward the appropriate number of leap seconds.

Each KAM/TCG/102/D or KAM/TCG/105 has a programmable number of leap seconds. The legacy KAM/TCG/102/C has 13 hard-coded leap seconds. That is, if this module is used in November 2012 (leap seconds at that time equaled 15), it steps forward two seconds within 12.5 minutes (as it receives a correction from the GPS satellites).

44.4 Examples of leap seconds and year settings

Example 1: A single Acra KAM-500 chassis with IRIG time source from a KAM/TCG/10x with the time server set to Master.

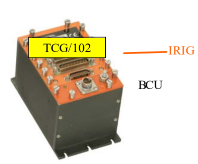

Figure 44-5: Year is set by the KAM/TCG/10x if iNET-X is used to transmit packets

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NOTE: The KAM/TCG/105 supports IRIG-B-200-04 as a setting in IRIG-B, which decodes the year. That is, it ignores the Current Year field in DAS Studio 3.

Example 2: A single Acra KAM-500 chassis with GPS time source from a KAM/TCG/10x with the time server set to Master.

Figure 44-6: Leap seconds are set by the KAM/TCG/10x

Example 3: KAD/BCU/xxx Ethernet controller modules configured as PTP clients, synchronized with a network switch PTP Grandmaster connected to GPS.

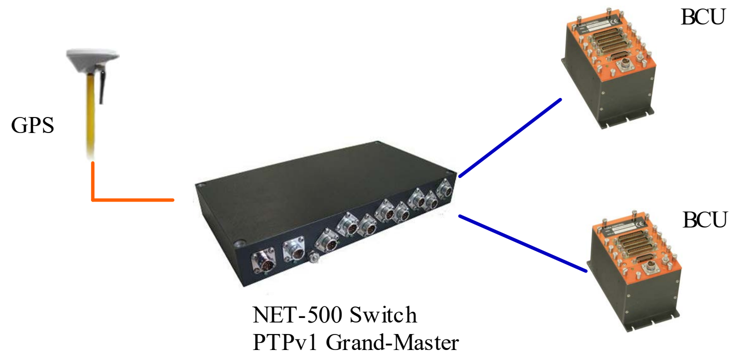

Figure 44-7: Leap Second is set by the network switch PTP Grandmaster

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NOTE: When the KAD/BCU/140/D is configured as a PTP client, the PTP Leap Seconds field in DAS Studio is ignored as this value is transmitted by the PTP Grandmaster.

Example 4: KAD/BCU/xxx Ethernet controller modules configured as PTP client, synchronized with a network switch PTP Grandmaster connected to IRIG.

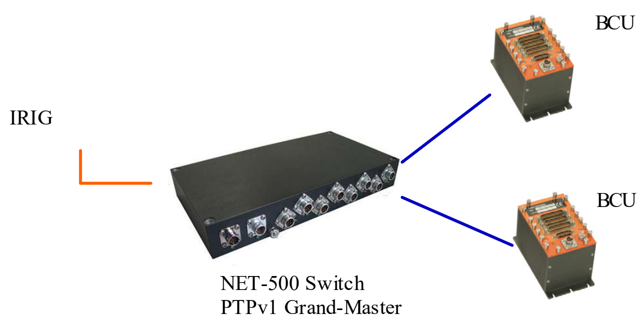

Figure 44-8: Year is set by the network switch PTP Grandmaster

Example 5: KAD/BCU/xxx Ethernet controller modules synchronized with a network switch PTP Grandmaster connected to an IRIG signal received from a KAM/TCG/10x with the time server set to Master.

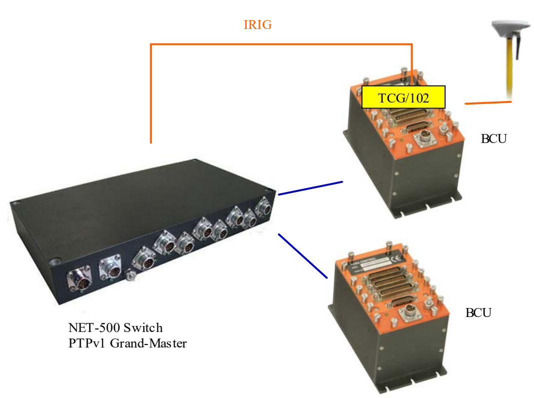

Figure 44-9: Leap Seconds are set by the KAM/TCG/10x; year is set on the KAM/TCG/10x

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NOTE: This is an atypical configuration when using a NET/SWI/101/C as a network switch and PTP Grandmaster.

Example 6: KAD/BCU/xxx Ethernet controller modules synchronized with a network switch PTP Grandmaster connected to an IRIG signal received from a KAM/TCG/10x with the time server set to Master. The year must be set by both the network switch PTP Grandmaster and the KAM/TCG/10x.

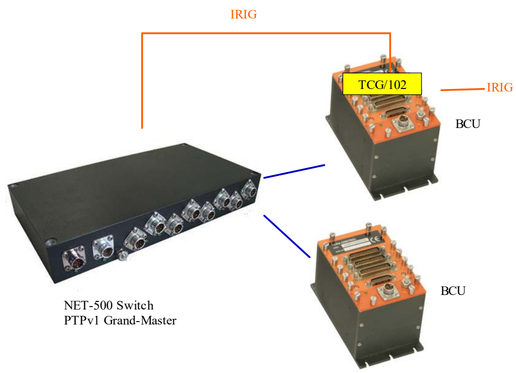

Figure 44-10: Year must be set by the KAM/TCG/10x and on the network switch PTP Grandmaster

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NOTE: In a synchronized PCM distributed system where the year is not carried over X_SYNC, the KAD/ETH/102 has an option to capture the Year from PTP.

44.4.1 Leap year on the KAM/TCG/10x

If IRIG is the time source, then Leap year is automatically programmed by DAS Studio 3 depending on the Current Year field set in DAS Studio.

When RTC/GPS is the time source, the module will calculate the time accordingly from this source.

44.5 Axon and time

The AXN/BCU/402 only proposes PTP time as a parameter, which is based on TAI. Unlike KAM-500 TCG cards, the AXN/TCG/401/B does not expose time as parameters.

IRIG time (UTC + Local Time) is only available as a parameter from the AXN/ENC/40x. The AXN/ENC/402 also supports the Year and Day of Year parameters. For more information, refer to *TEC/NOT/089 - Using DAS Studio 3 to configure the AXN/ENC/402*.

The AXN/BCU/402/C supports Local Time, however this local time is not carried over PTP so any AXN/BCU/402 modules in the system must contain the same Local Time.

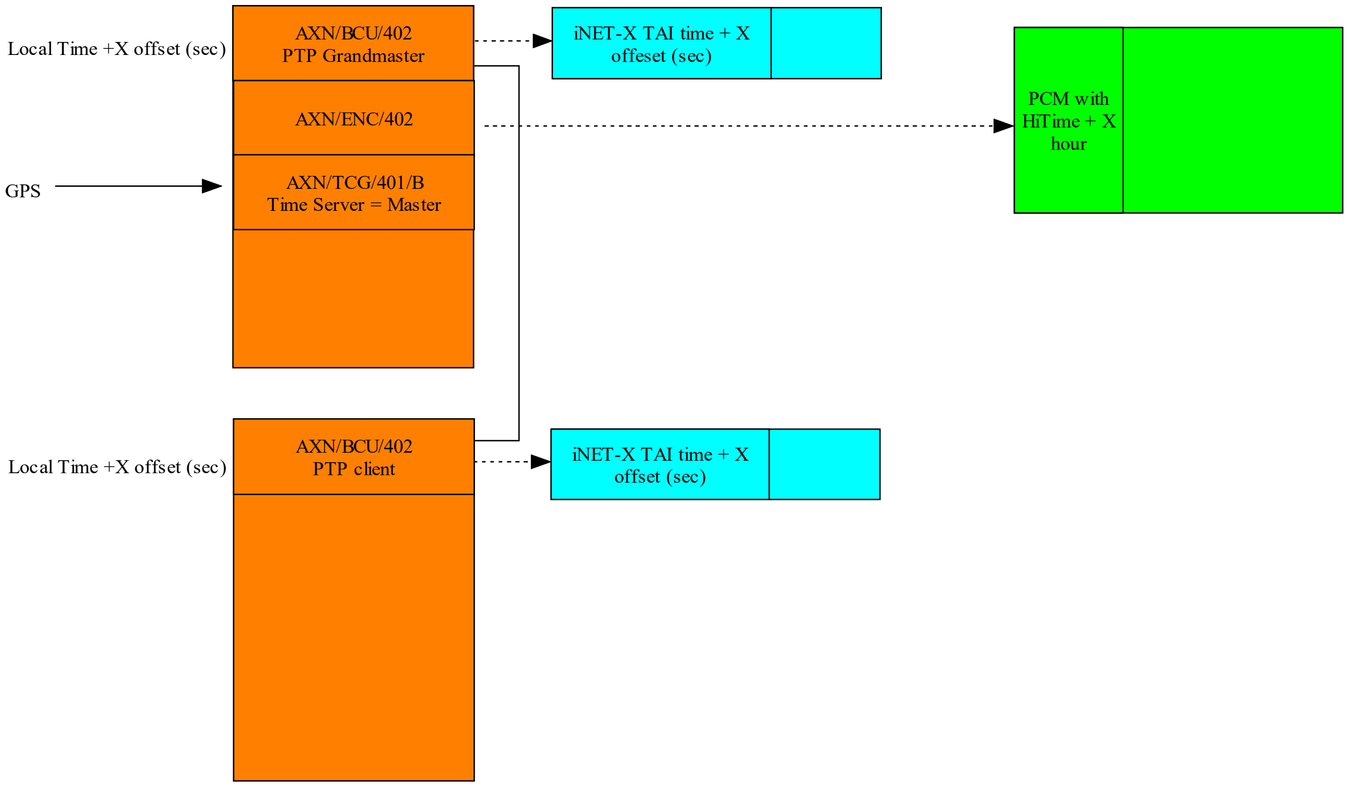

Figure 44-11: Example of Local Time settings and how it is applied to different outputs

For example, if a NET/REC/00x is connected to the AXN/BCU/402 Grandmaster, the time in the display will not have the local time because the display is calculating the time (UTC) on the PTP communication.

A KAM-500 does not support Local Time, therefore Local Time cannot be used in an Axon/KAM-500 hybrid system.